USGS

**WATER RESOURCES RESEARCH GRANT PROPOSAL**

**Title:** Implementation of methods to enhance the evaluation of the effectiveness of current BMPs in controlling stormwater discharges from mall construction sites in the Valley and Ridge physiographic region and the development of metrics to assess the effects of discharge on stream communities

**Focus Category:** SED, WQL, ECL

**Descriptors:** erosion, erosion control, construction, sediments, fish communities, invertebrate communities, bioassessment

**Duration:** March 1, 2000 to February 28, 2001

**Federal Funds:**

| | | |
|---|---|---|
| $24,975.49 | $24,975.49 | $0 |
| (Total) | (Direct) | (Indirect) |

**NonFederal Funds:**

| | | |
|---|---|---|
| $59,954.99 | $34,209.51 | $25,745.48 |
| (Total) | (Direct) | (Indirect) |

**Principal Investigator:**

Ken R. Marion (PI), Biology Department, University of Alabama at Birmingham, Birmingham, AL 35294-1170

**Coinvestigators:** Robert Angus (Biology Department), and Melinda Lalor (Department of Civil and Environmental Engineering) UAB

**Congressional District:** VI

**Water Problem and Need for Research**

As population expansion and increasing development occur in the Southeast, stormwater runoff from construction sites has become an increasingly major contributor to siltation input into our streams and rivers. While large construction projects represent single major potential pollution sources and are usually more visible, smaller construction sites (usually future home sites <5 acres) are both more numerous and are less likely to employ adequate erosion control best management practices (BMPs). By far the most common BMPs employed at such sites are plastic silt fences and hay bales. Although factors controlling erosion processes are well known, few scientific studies have been performed to evaluate the effectiveness (or lack of it) in the field of such BMPs, especially as affected by physical site and rainfall characteristics. This is especially true for the more upland and hilly terrain regions of Alabama and the Southeast. Information on the effectiveness of such BMPs in hilly terrain situations and the factors influencing the effectiveness is needed to assist in the selection of appropriate BMPs and the design of future erosion controls. Such information would be directly useful to federal, state and local regulatory agencies charged with the protection of aquatic environments.

Additionally, in order to adequately evaluate the effectiveness of silt fence erosion control, assessments of the runoff on receiving streams or drainages are needed. Although a number of bioassessment metrics are available and commonly used, some metrics are more responsive to some stressors than others and are known to vary between physiographic regions. There is a critical need to develop or refine such metrics so that they are more sensitive biocriteria from which a more refined discrimination can be made between the level of impairment between sites. Such improved metrics will assist in the selection and design of improved erosion control devices.

These objectives address the major water resource problems of Alabama (as recognized by the Water Resources Advisory Committee, 1992) of determining the effects of current, common BMPs on water quality, evaluating the impacts of erosion/sedimentation, and correlating sediment characteristics to geology, slope and land use. Further, the above objectives are in accord with stated Southeastern Region water priorities (3/25/96) for the protection of water from degradation by nonBpoint sources and soil erosion and the need for research on the ecological balance of aquatic communities.

**Expected Results, Benefits, Information, etc.**

Data collected in this preliminary study will allow us to identify the physical site and rainfall characteristics that appear most likely to influence the effectiveness of inBplace erosion control silt fences on small construction sites. Few studies have evaluated the field effectiveness of such BMPs, especially in the Valley and Ridge Physiographic Region (typical of upland and hilly terrain regions of much of northeast Alabama and a good portion of the Southeast). Our working hypothesis is that current BMPs are not very effective in this region of the country. The final report for this study will be made available to the Alabama Department of Environmental Management, the Jefferson County Stormwater Authority and other potentially interested agencies involved in formulation of regulations involving stormwater runoff. The data obtained in this research project will also be used in the preparation of a more comprehensive proposal to be submitted to the U.S. Environmental Protection Agency in which the assessment of other, potentially more effective, erosion control procedures would be included. Such information on field effectiveness and influencing factors would assist federal, state, and local regulatory agencies (who are charged with the protection of aquatic environments) in the selection of appropriate BMPs and the design of future erosion control systems. Additionally, improved erosion control methods would greatly benefit stream biological communities by improving water/habitat quality.

Bioassessment metrics calculated for streams receiving differing quantities of silt will allow for the preliminary identification of metrics most sensitive to variations in siltation. Our initial data will be used to strengthen a proposal to the U.S. EPA to support a more comprehensive screening of such metrics. The ultimate objective is the development and validation of metrics that permit a more refined discrimination between sites with varying levels of impairment. Ultimately, the confidence with which a judgment of biological conditions can be made using biocriteria depends upon the soundness and scientific validity of the metrics selected and tested. Metrics that are poorly defined or based on a flawed conceptual basis provide erroneous judgments with the potential for poor management decisions. The development of improved metrics will allow for an adequate assessment of the effects of runoff from construction sites. Ideally, such information would be useful in the selection and design of future BMPs.

**Nature, Scope and Objectives**

Excessive input of fine sediment (e.g. silt, fine clay particles, fine sand) is generally considered to be the most prevalent form of pollution currently affecting streams and rivers in the United States (Brooks et al., 1991; Waters, 1995; Wang et al., 1997; Woodward and Foster, 1997). It has now also come to be recognized as a serious problem in the Southeast (Shepard et al., 1995; Waters, 1995). Because of the erosive force of flowing waters, the presence of some fine sediments in certain types of streams is an entirely natural phenomenon. A dynamic balance normally exists between the particle size and the amount of sediment transported by a stream, and the discharge and slope gradient of the stream. However, a number of human activities can result in considerably elevated rates of sediment input, upsetting this balance and resulting in increased turbidity (suspended sediments in the water column) and increased deposition of sediment on the stream bottom. Both of these factors are known to have serious adverse effects on the ecology of streams and their biological communities. Studies have shown that high turbidity levels and significant sediment deposits can clog the gills of some benthic macroinvertebrates and disrupt their feeding behaviors (Hawkes, 1979; Hellawell, 1986). Similarly, populations of creviceBspawning fish species and visualBfeeding fish species can be seriously impacted or eliminated in waters with increased turbidity and bottom sediment deposition (Karr et al., 1985; Mettee et al., 1996). Thus, increased turbidity and siltation likely leads to decreased abundances for some species, a decreased stream diversity, altered stream community structures and significant food chain disruptions (Hellawell, 1986; Waters, 1995).

In addition to potential biological effects, excessive inputs of fine sediments into streams can have significant indirect economic effects. The value of streamside property is reduced if the water and habitat quality of the stream becomes degraded. Streams so affected often suffer reductions in recreational activities, such as canoeing and fishing, which are an important economic resource for Alabama and the Southeast in general (Birmingham News, May 31, 1997).

The major anthropogenic sources of sedimentation are agriculture, forestry, mining, and urban development. It has been estimated that agriculture contributes about 50% of all sediment input into streams of the United States (Brooks et al., 1991). However, an increasingly major source is urban development(Waters, 1995). Sediment production by urban development may still be small in terms of continental area, but effects on nearby streams can be severe. Rates of soil losses from construction sites have been reported many times higher than those from either forest or agricultural sources (Yorke and Herb, 1978; Waters, 1995). As suburban communities increasingly spread out over the countryside, development encroaches upon numerous streams and rivers. This sort of expansive development (e.g., Atlanta, Charlotte, Knoxville, Birmingham, etc.) is becoming an increasingly major problem for streams in many areas of the Southeast, including Alabama, especially where the terrain is hilly and soil porosity poor (Shepard et al., 1995; Waters, 1995; Lindsey, 1998; Onorato et al., 1998a).

Stormwater runoff from construction sites has been identified as a major contributor to sediment input in streams and rivers (Brooks et al., 1991; Shepard et al., 1995; Nelson, 1996). While large construction projects represent single major potential pollution sources and are usually more visible, smaller construction sites (usually future home sites <5 acres) are both more numerous and less likely to employ adequate erosion control best management practices (BMPs). By far the most common BMPs employed at such sites are plastic silt fences and hay bales. Although recommended BMPs exist for small construction sites (Alabama Department of Environmental Management, 1989; Alabama Soil and Water Conservation Committee, 1993), few scientific studies have been performed to evaluate the effectiveness of such BMPs, especially as affected by physical site and rainfall characteristics (EPA, 1987; EPA Office of Wetlands, Oceans and Watersheds, 1992; EPA Office of Water, 1992; Courtemanch, 1995). This is especially true for the more upland and hilly terrain regions of the Southeast, where rainfall is often intense (Courtemanch, 1995). Additionally, although a number of studies have been done on the effects of fine sediments on aquatic organisms (for summaries see Hellawell, 1986, Rosenberg and Resh, 1993, and Waters, 1995), much less is known concerning the relationship between the quantity and quality of siltation and the effects on habitat quality and the makeup of the aquatic communities (Brown et al., 1997; Wang et al., 1997). Specifically, although certain current bioassessment metrics (quantitative measure of the community that provide an overall indication of biological condition or Ahealth@) are more responsive to specific stressors than others (Barbour et al., 1995), there is a critical need to develop or refine such metrics so that they are more sensitive biocriteria from which a more refined discrimination can be made between the level of impairment between sites (Barbour et al., 1995; Simon and Lyons, 1995). Complicating this problem is that some metrics are recognized to be more effective in evaluating specific stressors in some physiographic regions than others (Simon and Lyons, 1995; Barbour et al., 1997). Ultimately, the confidence with which a judgment of biological conditions can be made using biocriteria rests with the soundness and scientific validity of the metrics selected and tested. Metrics that are poorly defined or based on a flawed conceptual basis provide erroneous judgments with the potential for erroneous management decisions (Barbour et al., 1995; Davis, 1995).

During 1999, we were funded by the Alabama Water Resources Research Institute to: 1) evaluate the effects of physical site conditions (soil type, slope, surface characteristics and topography) and significant rainfall conditions (such as intensity and duration) on erosion losses from small construction sites, while characterizing such runoff in terms of total solids (suspended and dissolved solids), turbidity, and particle size distribution; 2) provide a preliminary assessment of the effectiveness of current BMPs (silt fences) in reducing sediment loading rates from small construction sites in the Valley and Ridge physiographic region of Alabama; and 3) study the relationship between varying amounts of sediment input loads and the impact on the biological communities of the receiving streams, thereby eventually allowing the development or refinement of biological metrics appropriate to adequately assess the effects of sediment runoff from construction sites on stream biota in the Valley and Ridge physiographic region. A summary of the preliminary results appears in the Progress Review section of this proposal. These preliminary results indicate substantial progress toward meeting the objectives and providing valuable insights into those specified problems. This proposal for Year 2000 seeks to build upon the findings achieved during 1999 by requesting funds to implement additional procedures and methodology. These new approaches should both augment and strengthen the original findings, and thus provide a higher degree of clarification of results and achievement of the objectives.

We propose to build upon the 1999 findings by: 1) establishing a site for experimental manipulation of silt fences under varying physical conditions (i.e., slope difference, size of disturbed area, age of disturbance, soil type); 2) employing HesterB Dendy plate samplers and quantitative multihabitat jab sampling to assess the pool benthic macroinvertebrate community in streams with varying degrees of sediment input (riffle community data collected in 1999); and 3) continuing and expanding the biological sampling on the most and least sedimentBaffected streams identified during 1999.

## PROGRESS REVIEW

### Effectiveness of Silt Fences

To date, we have collected approximately 80 water samples during rain events from numerous locations throughout the greater Birmingham area. These samples are a mixture of three collection types: runoff below silt fences, runoff below construction sites with no silt fences (or at some sites, above the silt fence), and runoff from vegetated areas nearby. Turbidity, total solids, and particle size measurements have been made on most of these samples. Although a complete analysis awaits the end of the collecting season, certain trends are evident. Turbidity measurements in the majority of the samples collected below construction sites with no silt fences are in the range of 4,000 - 6,000 NTU=s. In the majority of the samples collected below well-maintained and properly constructed silt fences, the turbidity values are about 25% less than the sites without fences. All values are much reduced in the runoff samples from vegetated slopes, with NTU values often less than 200. A preliminary evaluation of suspended particle sizes indicates a large percentage of the runoff sample consists of very small clay particulates. After all the samples are analyzed, we will utilize multiple regression techniques to assess the relationships between the physical and environmental factors of the sites and the effectiveness of the silt fences in improving runoff quality.

## Biological Impacts of Siltation

During 1999, six tributaries with varying sediment loads (2 low, 2 moderate, 2 high) were biologically assessed during spring. Fall assessments are nearing completion as of this writing. Physical measurements and habitat evaluations were performed using EPA rapid bioassessment protocols and sediment measurements were taken. Complete data analysis awaits the completion of the fall sampling and identification period. Preliminary analysis of the fish biota indicate that various metrics used to evaluate the biological integrity of the fish community (IBI), are altered in the most sedimented streams. In these streams, the proportion and biomass of darter species is lower, the proportion and biomass of sunfish species is higher, the ShannonBWeiner diversity index is lower, and the number of tolerant species higher. Statistical analyses, including regression correlations of a number of measured metrics with habitat quality and sediment loaded will be performed when the entire year=s collections are complete. The complete benthic macroinvertebrate analysis for a variety of metrics also awaits the completion of the fall collection/identification period. However, the spring collections on the six tributaries have been analyzed as a part of a graduate student study of a variety of Cahaba tributaries (includes several other streams). Several metrics (Sorenson=s Community Similarity Index, ShannonBWeiner Diversity Index, Ratio of EPT to (EPT plus Chironomidae), % chironomids, Jaccard Coefficient, and Hilsenhoff Biotic Index) reach their highest or lowest levels in the two streams with the most sediment load. Although Spearman Rank Correlations of each of these metrics for all streams studied (several more than in this proposal) with several measures of sedimentation do not show statistical significance ($p<0.05$), the p values range from 0.07 to 0.20, indicating definite trends. We await the results of just the streams in this study. Based on these preliminary data, it is felt that clarification of those metrics most sensitive to sediment input, and hence potentially useful as a practical measure of stream impact due to construction runoff, would be greatly enhanced during 2000 by: 1) concentrating on additional bioassessment of those streams at either end of the sediment load spectrum (the two lowest and two heaviest); and 2) evaluating the pool macroinvertebrates for inclusion in the metric analyses (just riffle biota were sampled in 1999). Although riffle biota are affected by sediment input, it is likely that alterations in quietBwater benthic macroinvertebrate communities may occur more quickly except in very heavily sedimented streams. Thus, the addition of these organisms for inclusion in the overall metric analyses may strengthen the evaluation of metrics most sensitive to sedimentation.

## Methods

Many factors likely influence the success or failure of current common BMPs (silt fences) on small construction sites. The methodology outlined below will measure or quantify the major influential factors involving physical aspects of the construction. Outcomes following intense rain events and over time will also be monitored by measuring and quantifying aspects of both the runoff and sediment deposition in the stream. The relationships between outcomes and physical aspects of the site will be subjected to multiple regression techniques to determine the relative importance of each factor in success or failure of the BMP.

**Study Sites**

This study will take place in the upper reaches of the Cahaba River basin in north central Alabama. We believe this is an ideal location to evaluate factors influencing the outcomes and impacts of silt fences for several reasons:

> 1) The surrounding land in this region is representative of the topography and soil types found throughout many of the upland physiographic regions in the Southeast (i.e., southern Appalachian and foothill areas). Thus, findings from this study should result in general applications to evaluate the effectiveness of the dominant BMPs for a large portion of the Southeast. Specifically, this section of the Cahaba is in the Valley and Ridge Province. This large physiographic region of the Southeast is composed of a series of parallel valleys and ridges composed of rocks chiefly of Cambrian, Ordovician, Mississipian and Pennsylvanian Ages. Slopes adjacent to the River are fairly to moderately steep and the dominant soils are clayBbased, often overlain by shallow clayBloam combinations. Not unlike other streams in this and other surrounding physiographic provinces in the Southeast, cobble, boulders and long stretches of bedrock are the predominant bottom substrates. The Cahaba River channel and its tributaries can be described as having relatively even ratios of riffles, runs and small pools. There is a moderate gradient drop in the main channel (averaging 10B12 feet/mile).
>
> 2) Rainfall amounts and intensities in this region are representative of many regions of the Southeast. Rainfall here averages 54 inches per year and covers the broadest possible spectrum in terms of intensity, duration and total volume. Intense heavy downpours are common in spring and summer, leading to significant water runoff from slopes.
>
> 3) The expanding suburbs of the metropolitan Birmingham area are rapidly encroaching upon the upper Cahaba and its tributaries. Until quite recently, this area was primarily rural and predominantly forested. Now, however, large numbers of home sites and subdivisions are being constructed along some areas of the upper Cahaba and its tributaries. Thus, numerous opportunities are available to study the effectiveness of silt fences and their influence on relatively pristine stretches of streams.

**Manipulation Of Silt Fences On An Experimental Plot**

In 1999, our objective was to compare the effectiveness of silt fences in preventing erosion from construction sites. Samples of runoff water were collected at various sites during periods of heavy rain (>1 inch/hour). Analyses of these samples is currently in progress. When the data are available, we will be analyzing the relationships between amount of silt in the runoff water and slope gradient, soil type, condition of the silt fence, etc. We will also compare runoff from cleared construction sites with nearby undisturbed areas. While we expect the results of these analyses to be informative, we also encountered some problems over the past year. These were primarily related to the fact that the study sites were scattered over the greater Birmingham area. Summer thundershowers can be extremely local. Thus, on numerous occasions, one site received a heavy rain and others much less. Although rain gauges were located nearby, not all sites had rain gauges located on site. This will affect the precision of our comparisons of runoff from various sites during the same event.

The late summer 1999 turned out to be exceptionally dry. The Birmingham area received no heavy rains from mid July until early October. This made it impossible to collect multiple samples from many of the sites. This was because, by the time a second or third rain event occurred, construction and landscaping had often been completed.

After discussions with several local construction and waste removal contractors we have identified a landfill in Walker County and have received tentative approval to place silt fences at selected locations below recently disturbed areas. Further, we may be able to experimentally manipulate other areas adjacent to the immediate landfill by creating small cleared areas in regions of varying slopes and soil types. Dr. Michael Vermace of the UAB Department of Civil and Environmental Engineering, who has had extensive training in soil analysis, has agreed to collaborate with us in the design and selection of our experimental plots. This will provide an opportunity to experimentally evaluate the effects of factors such as gradient of slope, size of disturbed area, age of disturbance, and soil type on surface runoff quality and the effectiveness of silt fences in reducing the amount of particulates in the runoff. A major advantage of such an experimental area is that we can compare various methods of silt control in a small geographic area where the amount of rainfall received during any particular event will be quite uniform. Since we can place an accurate rain gauge in this location, this will make it easier to make valid comparisons between rainfall intensity and the effectiveness of silt fences in different physical conditions.

Physical features of the study site will be characterized. These features include: slope angle, soil type and porosity, topography, and percent and type of vegetative cover in the periphery. The dominant slope angle will be determined by simple survey techniques. The topography of the site and the immediate peripheral area will be mapped in three dimensions using a combination of survey and GPS techniques. Soil cores will be taken and basic soil analyses will be performed at the UAB Environmental Engineering Laboratory (in the Department of Civil and Environmental Engineering). Soils will be characterized for classification type and porosity. Distance of the BMP from the disturbed site will be measured and the peripheral vegetative type and cover will be evaluated on a quantitative scale used for EPA Rapid Bioassessment Protocols (Barbour et al., 1997). Additionally, the time since the date of land clearing will be noted.

Stormwater runoff samples will be collected from each of the experimental areas during five to ten Aintense@ rain events. Intense rain events will be defined as $1 inch/hr. Rainfall events <1 inch/hr will not be studied. Runoff will be collected by funnels. These devices typically collect most of their sample early on in a rain event, when the greatest load is likely to occur. Rainfall intensity, duration and volume will be measured using recording tipping bucket rain gauges. Collected runoff samples (from below silt fences, from cleared areas with no silt fences, or from nearby vegetated areas) will be analyzed at the UAB Environmental Engineering Laboratory for turbidity (using a nephelometer), particle size distribution (using a Coulter counter), and total solids (dissolved solids and suspended solids, using methods 2540B and 2540C in Standard Methods for Examination of Water and Wastewater; NSTM, 1998). This portion of the study will be done in collaboration with Dr. Vermace who has extensive experience in evaluating soil runoff characteristics. The observed sediment loading will be calculated for each sample using an estimated runoff volume and suspended solids concentration from the sampling data. Runoff for individual storm events will be estimated using Soil Conservation Service method TRB55 (SCS, 1986). The Universal Soil Loss Equation (USLE) will be used to predict sediment loadings for each location (Brooks et al., 1991).

Multiple regression techniques will be used to evaluate the associations between physical characteristics of the site and the quality and quantity of the runoff. This procedure will provide a valuable supplement to the data collected in 1999 and will allow us to determine the relative importance of each factor in success or failure of the BMP. Additionally, the effectiveness of the BMPs will also be evaluated by calculation of the sediment delivery ratio (observed sediment loading/predicted sediment loading) (Brooks et al., 1991).

**Bioassessments of silt-impacted and -unimpacted sites**

We will extend the bioassessment studies we began in 1999, but will narrow our focus to the two most silt-impacted sites and the two least silt-impacted sites. Comparisons between these extreme sites should give us the clearest picture of the effects of siltation on the biological integrity of a stream.

Studies (described below) will be performed in the spring, after the period of winter rains (to evaluate immediate effects), and again the following summer and fall (to evaluate delayed effects). Such a sampling regime will also allow us to account for seasonal community structure changes in benthic macroinvertebrates.

Physical characterization and habitat assessment - An evaluation of habitat quality is an important component of the assessment of the ecological integrity of a site (Barbour et al., 1997). This information not only allows one to quantify the degree of impairment between sites, but is also critical if one is to make meaningful comparisons between a reference (unimpacted) site and a potentially impacted one. For each of the four sites, we will follow EPA-recommended procedures for habitat assessment of high gradient streams, as outlined in the Revision to Rapid Bioassessment Protocols for Use in Streams and Rivers (Barbour et al., 1997) and those adopted by the Alabama Department of Environmental Management. We have used these procedures in our 1999 studies.

Variables are assessed according to numerical scales ranging from optimal to poor conditions and are weighted to emphasize those considered most biologically significant.

A similar, but relatively unimpacted reference site (either external or internal) is used to normalize the assessment to the Abest attainable@ situation. The total score obtained for a station is compared to that of the unimpacted reference site. The difference provides a quantitative estimate of the degree of site-specific habitat alteration.

Variables specifically evaluated for sediment effect will be: degree of embeddedness, extent of channel alteration, and degree of sediment deposition in pools (Barbour et al., 1997). Mean sediment depth in pools at each site will be measured by averaging 10 core samples (or by direct measurement using a meter stick, when possible).

Additional habitat variables will be: surrounding land use pattern, degree of local erosion, substrate and instream cover, riffle quality, pool/riffle and run/bend ratios, bank vegetative cover, bank stability and riparian vegetative zone width (Barbour et al., 1997). Stream width, stream depth, pH, conductivity and water velocity will also be recorded.

Benthic macroinvertebrate surveys - Benthic macroinvertebrates are good indicators of local stream conditions because of their generally sessile mode of existence. Additionally, many taxa are sensitive to stresses, such as siltation (Hellawell, 1986; Waters, 1995). Thus, the community structure and the relative proportions of various functional feeding groups at a site reflect the degree of habitat/water quality alteration (Barbour et al., 1997).

We will use EPA Rapid Bioassessment Protocols as outlined in the Revision to Rapid Bioassessment Protocols (RBP) for Use in Streams and Rivers (Barbour et al., 1997). We have had extensive experience using these protocols on the Cahaba and its tributaries (Onorato, 1997; Onorato et al., 1998a; Onorato et al., 1998b; Lindsey, 1998). This protocol provides quantitative data which can be used in monitoring future trends in the benthic community as conditions change. Specifically, we will adopt a slightly modified version of the multihabitat approach. Even though sampling riffles alone would be justified, as cobble and other rocky material make up more than 30% of the bottom substrate (Barbour et al., 1997) in the upper reaches of the Cahaba and its tributaries, sedimentation effects on benthic macroinvertebrates are often more dramatically observed in pools (Hellawell, 1986). Thus we will collect benthic invertebrates from both riffle and pool habitats using the EPA multihabitat approach (Barbour et al., 1997). In this approach, benthic macroinvertebrates are collected systematically from all available instream habitats, not just riffles. A total of 20 jabs (or kicks) are made with a D-frame dip net, resulting in a sampling of approximately 3 $m^2$ of habitat.

Additionally, we will use Hester-Dendy plate samplers to sample the macroinvertebrate populations in the pools. These are stacks of masonite plates that serve as a substrate on which larval invertebrates can colonize. The rate of colonization and the species diversity are indicative of the health of the population producing the colonizing individuals. It is likely that the pool habitats are more heavily impacted by siltation than riffles. This is because the current velocity in riffles tends to scour them clean of small particulate matter which then accumulates in the pools. The Hester-Dendy plate samplers will be placed in a pool at each site approximately three months before the site is to be sampled.

This will allow adequate time for the plates to be colonized by invertebrates. Then, during each sample, four of the samplers will be taken, placed in ethanol, disassembled and the macroinvertebrates carefully removed.

The benthic invertebrates obtained by all collection methods at a site will be composited and a 200-organism random subsample will be taken from each composited sample using the modified subsample procedures described in Barbour et al. (1997). This consists of evenly distributing the composite sample onto a pan marked with a numbered grid pattern. Grids are then randomly selected and all organisms within each selected grid removed until at least 200 organisms have been obtained. Previous studies have determined that subsamples of 100 or more are sufficient to provide a representative estimate of the benthic fauna (Barbour et al., 1997; Nuzzo, 1986; Bode, 1988; Shackleford, 1988).

A number of metrics recommended in the EPABrecommended Rapid Bioassessment Protocol (Barbour et al., 1997) will be used to evaluate the structure and status of the benthic macroinvertebrate community. Included among these will be: genus richness (a measure of diversity); modified Hilsenhoff biotic index (a measure of overall pollution tolerance of the benthic community; ratio of scrapers to filtering collectors (a measure of feeding group modification by disturbance factors); ratio of functional feeding groups; ratio of Ephemeroptera, Plecoptera and Trichoptera (EPT) to chironomid abundance ( a measure of community balance as a reflection of possible disturbance); percent contribution of dominant taxon (an indirect measure of diversity); EPT Index (an indication of abundance of relatively pollution tolerant groups); and community similarity indices (as compared to the reference site and each other). The above metrics have been reasonably widely used to assess benthic macroinvertebrate communities (Barbour et al., 1997) and have also been used in recent bioassessment studies performed by our group at numerous stations on the Cahaba and its tributaries (Lindsey, 1998).

<u>Fish biosurveys</u> - The ichthyofaunal community also responds to habitat/water quality alteration (Karr, 1981; Barbour et al., 1997). Fish are better indicators of longer-term stresses since they generally live longer than most aquatic invertebrates. Additionally, since fish communities include species representing a variety of trophic levels, they tend to integrate effects on lower levels. Thus, fish community structure reflects overall environmental health.

We will employ a modification of the EPA Rapid Bioassessment Protocol outlined in the Revision to Rapid Bioassessment Protocols for Use in Streams and Rivers (Barbour et al., 1997). This procedure adopts the multihabitat approach, which allows for the sampling habitats in relative proportion to their local availability.

Fish will be collected at each site by the use of two gears: a backpack electrofisher (SmithBRoot) and small seines (these are small streams; 6 x 10 feet, 1/8 inch mesh for pools; 4 x 6 feet, 1/8 mesh for riffles). Although EPA-recommended RBP recognizes that electrofishing is the single most comprehensive and effective method for the collection of stream fishes, we will also employ seining for a number of reasons. Our previous work on the Cahaba and its tributaries has employed a combination of the two gears and other recent (Shepard et al., 1995) and virtually all previous samples (Samford University and University of Alabama collections) have employed seines. Thus, the use of seines will allow for a more accurate comparison to recent and historical data from these areas. Our recent research has shown that the two gears collect different types of fish with different efficiencies and that combined use of both gears provides a more complete assessment of the ichthyofauna at a site (Onorato et al., 1998b).

Each method of collection will be employed for 30 minutes over all of the wadeable habitats within the stream stretch. Fish will be identified and enumerated on site and released alive. The fish will be separated by families and the biomass of each will be determined. Voucher specimens and individuals of uncertain identification will be preserved in 10% formalin for further study. We have an extensive collection of voucher specimens from previous work on the upper Cahaba and its tributaries.

Data analysis will employ the Index of Biotic Integrity (IBI), a fish assemblage assessment approach developed by Karr (1981). For comparative purposes, we will use a slight modification of the IBI that was developed by Shepard et al. (1995) specifically for the Cahaba River and its tributaries. We have also employed this modification in our recent studies. This IBI uses 12 metrics to assess biological integrity based on abundances, and the taxonomic and trophic composition of the fish community. Each metric is scored against criteria obtained from an appropriate reference site (either internal or external). The metrics used are: total number of fish species (decreases with habitat degradation); number of darter species (a relatively disturbanceBsensitive group); number of sunfish species (decrease with degradation of pools and instream cover); number of minnow species (commonly most of fish biomass in small streams; an indication of diversity); number of sucker species or bottomBfeeding species (an indication of a trophic level group); number of intolerant species (as defined by Shepard et al. [1995]; an indication of disturbance); proportion of individuals as sunfish (goes up with moderate disturbance, as sunfish are relatively tolerant); proportion of individuals as insectivorous minnows (decreases as insect community decreases due to siltation); proportion of individuals as top carnivores (indicates trophic abundance shifts); number of individuals collected per hour of effort (evaluates abundance); and total biomass collected per hour effort. Additionally, several standard species diversity and richness indices will be calculated (e.g., ShannonBWiener, etc.).

<u>Evaluation and development of metrics to assess biological impairment resulting from siltation</u> - The metrics for both benthic macroinvertebrates and fish generated from data obtained at the sampling sites (representing differing levels of sedimentation input) will be evaluated for their degree of sensitivity to sediment input. Based on preliminary evaluation of data collected in 1999, we have identified some metrics that appear to be especially useful in identifying biological systems that have been impacted by sediment in the Valley and Ridge Physiographic Region. These biological metrics are correlated with the degree of siltation at various sites, as indicated in the habitat analyses.

By focusing on relatively pristine vs. highly silted sites, we should be able to improve on our ability to identify the metrics that are most sensitive indicators of silt-induced stresses on aquatic communities. This information should prove useful in improving our ability to evaluate the environmental effects of silt on aquatic systems and also should be useful as a source of information in formulating watershed management plans in this region of the country.

**Facilities and Equipment**

The UAB Environmental Engineering Laboratory is equipped with stateBofBtheBart instrumentation (e.g., Coulter counter, nephelometer, etc.) to measure the water quality parameters appropriate to this research proposal. Technicians and graduate students are trained to assure QA/QC by following EPA protocol for storage, preservation and analysis and conforming to ASTM standards of analysis for precision and accuracy. The Laboratory follows these policies, which are summarized in a document entitled AQuality Assurance Project Plan: Effects, Sources and Treatment of Stormwater Samples@ (Parmer and Pitt, 1995).

The UAB Biology Department has the necessary sampling gear to carry out the biological aspects of the project. Equipment available for this study include a SmithBRoot Model 15BC backpack electroshocker, a YSI 51B dissolved oxygen meter, a YSI salinityBconductivity meter, an Orion SA 250 pH meter, waders (old), seines and most necessary field items. The Department has a wellBequipped ecology laboratory with two researchBquality stereo microscopes (Leica MZ6 and Olympus XBTr) which will be used for identifying macroinvertebrate specimens. A number of taxonomic keys are available to assist in identifying macroinvertebrates and fish. Statistical analysis of data will be done using SYSTAT (v 8.0 for Windows) statistical software. Microsoft Excel spreadsheet software will be used for data maintenance and analysis.

**Related Research**

Although much is known concerning the factors influencing erosion processes (Alabama Department of Environmental Management, 1989; Brooks et al., 1991; summary in EPA Office of Water, 1992; Alabama Soil and Water Conservation Committee, 1993), few scientific studies have been performed to evaluate the field effectiveness of BMPs such as silt fences, especially as affected by physical site and rainfall characteristics (EPA, 1987; EPA Office of Wetlands, Oceans and Watersheds, 1992; EPA Office of Water, 1992; Courtemanch, 1995; Nelson, 1996). This is particularly true for the more upland and hilly terrains of Alabama and the Southeast in general (Courtemanch, 1995). This proposal will extend and improve on the results of our 1999 study on the effectiveness of silt fences and factors influencing their effectiveness (or lack of it) in such terrain.

Fine sediments are known to affect aquatic organisms in many ways (for summaries see Hellawell, 1986; Rosenberg and Resh, 1993; and Waters, 1995). However, much less is known concerning the relationship between the quantity and quality of the siltation and the effects on the makeup of the aquatic community structure (Brown et al., 1997; Wang et al., 1997). A number of bioassessment metrics are commonly used to evaluate the status of aquatic communities and some metrics are known to be more responsive to specific stressors (for summaries see Barbour et al., 1995 and Barbour et al., 1997). However, there is a critical need to develop or refine such metrics so they are more sensitive to detecting the level of impairment between sites (Barbour et al., 1995; Simon and Lyons, 1995). Further, some metrics are recognized to be more effective in evaluating specific stressors in some physiographic regions than others (Simon and Lyons, 1995; Barbour et al., 1997). The studies outlined in this proposal are intended to tentatively identify those metrics that appear to be most useful in evaluating the effects of siltation runoff below construction sites on biological communities.

**Literature Cited**


Alabama Department of Environmental Management. 1989. Alabama NonBpoint Source Management Program. April, 1989.

Alabama Soil and Water Conservation Committee. 1993. Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas. July, 1993.

Barbour, M.T., J.B. Stribling and J.R. Karr. 1995. Multimetric approach for establishing biocriteria and measuring biological condition. *In* Biological Assessment and Criteria. CRC Press, Boca Raton, FL. 395 pp.

Barbour, M., J. Gerritsen, B. Snyder and J. Stribling. 1997. Revision to Rapid Bioassessment Protocols for Use in Streams and Rivers. EPA 841B2B97B002.

Birmingham News. May 31, 1997. The big ten in recreational activities of the South.

Bode, R.W. 1988. Quality assurance workplan for biological stream monitoring in New York state. New York State Department of Environmental Conservation.

Brooks, K.N., P.F. Falliott, H.M. Gregersen and J.L. Thames. 1991. Hydrology and the Management of Watersheds. Iowa State University Press, Ames. 392 pp.

Brown, A.V., Y. Aguila, K.B. Brown and W.P. Fowler. 1997. Responses of benthic macroinvertebrates in small intermittent streams to silvacultural practices. *Hydrobiologia* 347:119B125.

Courtemanch, D.L. 1995. Merging the science of biological monitoring with water resource management policy:< criteria development. *In* W.S. Davis and T.P. Simon (eds.), Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Pages 315B325. Lewis Publishers, Boca Raton, Florida.

Davis, W.S. 1995. Biological assessment and criteria: building on the past. In Biological Assessment and Criteria. CRC Press, Boca Raton, FL. 395 pp.

EPA. 1987. Draft Report on Best Management Practices for the Control of Storm Water from Urbanized Areas. Science Applications International Corporation. June 1987.

EPA. 1992. A Current Assessment of Urban Best Management Practices: Techniques for Reducing NonBpoint Source Pollution in the Coastal Zone. Office of Wetlands, Oceans and Watersheds, prepared by Metropolitan Washington Council of Governments. June 1992.

EPA. 1992. Storm Water Management For Construction Activities: Developing Pollution Prevention Plans and Best Management Practices. Office of Water. EPA 832BRB92B005. September 1992.

Hawkes, H.A. 1979. Invertebrates as indicators of river water quality. *In* A. James and L. Evison (eds.), Biological Indicators of Water Quality, Chapter 2. John Wiley, Chichester, England.

Hellawell, J.M. 1986. Biological Indicators of Freshwater Pollution and Environmental Management. Elsevier Applied Science Publishers, New York, New York. 546 pp.

Karr, J.R. 1981. Assessment of biotic integrity using fish communities. *Fisheries* 6:21B27.

Karr, J.R., L.A. Toth and D.R. Dudley. 1985. Fish communities of midwestern rivers: a history of degradation. *Bioscience* 35:90B95.

Lindsey, K. 1998. A bioassessment of the upper Cahaba River using benthic macroinvertebrate populations. M.S. Thesis, University of Alabama at Birmingham.

Merritt, R.W. and K.W. Cummins (eds.), 1984. An Introduction to the Aquatic Insects of North America, Second edition. Kendall/Hunt Publishing Co., Dubuque, Iowa. 722 pp.

Mettee, M.F., P.E. O'Neil and J.M. Pierson. 1996. Fishes of Alabama and the Mobile Basin. Oxmoor House, Birmingham, AL.

Nelson, J.A. 1996. Characterizing erosion processes and sediment yields on construction sites. Unpublished M.S. Thesis, University of Alabama at Birmingham. 93 pp.

NSTM (National Society for Testing and Materials). 1998. Standard methods for examination of water and wastewater.

Nuzzo, R. 1986. Macroinvertebrate rapid assessment methodology. Mass. Viv. WPC.

Onorato, D. 1997. Ichthyological bioassessment of the upper Cahaba River of Alabama: an analysis of the selection of sampling gears, current trends in fish assemblages, and historical changes within the ichthyofaunal communities. M.S. Thesis, University of Alabama at Birmingham.

Onorato, D., K. Marion and R. Angus. 1998a. Longitudinal variations in the ichthyofaunal assemblages of the upper Cahaba River: possible effects of urbanization in a watershed. *Journal of Freshwater Ecology* 13(2):139-154.

Onorato, D.P., R.A. Angus and K.R. Marion. 1998b. Comparison of a smallBmesh seine and a backpack electroshocker for evaluating fish populations in a northBcentral Alabama stream. *North American Journal of Fisheries Management* 18:361-373.

Parmer, K. and R. Pitt, 1995. Quality Assurance Project Plan: Effects, Sources and Treatment of Stormwater Samples. Office of Research and Development, U.S. EPA, 163 pp.

Rosenberg, D.M. and V.H. Resh. 1993. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York, New York. 488 pp.

SCS (Soil Conservation Service). 1986. Urban Hydrology for Small Watersheds. U.S. Dept. of Ag. Tech. Release No. 55. June, 1986.

Shackleford, B. 1988. Rapid bioassessments of lotic macroinvertebrate communities: biocriteria development. Arkansas Department of Pollution Control and Ecology, Little Rock, Arkansas.

Shepard, T.E., P.E. O'Neil, S.W. McGregor and M.F. Metee. 1995. Water quality and Biomonitoring Studies in the Upper Cahaba River Drainage of Alabama. 1989B94. Geological Survey of Alabama, Tuscaloosa, AL. 287 pp.

Simon, T.P. and J. Lyons. 1995. Application of the Index of Biotic Integrity to evaluate water resource integrity in freshwater ecosystems. *In* Biological Assessment Criteria. CRC Press, Boca Raton, FL. 395 pp.

Wang, L., J. Lyons, P. Kanehl and R. Gatti. 1997. Influences of watershed land use on habitat quality and biotic integrity in Wisconsin streams. *Fisheries* 22(6):6B12.

Waters, T.F. 1995. Sediment in streams: sources, biological effects and controls. American Fisheries Society Monograph 7, Bethesda, MD. 251 pp.

Woodward, J. and I. Foster. 1997. Erosion and suspended sediment transfer in river catchments B environmental controls, processes and problems. Geography 82(part 4):353B376.

York, T.H., and J.W. Herb. 1978. Effects of urbanization on streamflow and sediment transport in the Rock Creek and Anacostra River basins, Montgomery County, Maryland, 1962-74. U.S. Geological Survey, Washington, DC.